



NEWS

Here comes the Snow!
— Spring 1995 —

DWR MISSION STATEMENT

To manage the water resources
of California, in cooperation
with other agencies,
to benefit the State's
people and protect,
restore and enhance
the natural and
human environments.



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H E R E C O M E S T H E SNOW

Snow — skiers love to plow through it, children delight in throwing it, and water supply forecasters eagerly anticipate it. For all of these people, lots of the white stuff is a good thing. But for the forecasters, an abundant snowpack is especially welcomed, for it could mean the difference between a runoff that leaves the state in a drought or one that provides an ample water supply for everyone.

In fact, more than 20 million



Californians and roughly 7 million acres of farmland depend on how much snow falls in the High Sierra. Too little snow and the State Water Project deliveries drop, leaving agricultural and urban water users to scramble for other resources like ground water—and in drastic cases, making mandatory rationing necessary. Too much snow and spring runoff can turn into more water than some downstream reservoirs can handle.

Whatever the case, knowing how much and what's in the snowpack go hand in hand with predicting whether the water year will be a good one or not. And the charge of collecting that information falls to snow surveying teams, under the Department's guiding hand.

BIRTH OF SNOW SURVEYING

The concept behind snow surveying took shape near the turn of the century with the work of Dr. James Church on Mount Rose, a 10,800-foot mountain in Nevada.

Based on his observations that there existed a relationship between snowmelt and the spring rise of Lake Tahoe, Church devised a method of systematically measuring the depth and water content of snow. And thus snow surveying was invented. (A historical monument near Lake Tahoe Dam commemorates Dr. Church's snow survey work which contributed to the end of the "Tahoe Water War.")

Water agencies soon picked up the idea and began their own surveying programs. With the data collected, they could now regulate releases to prevent flooding or conserve flows for downstream uses later in the year and keep their customers happy.

In 1929, the State Legislature, recognizing the need for a centralized system to provide information

to water users statewide, passed a bill that established the California Cooperative Snow Surveys Program and designated the Division of Water Resources (now DWR) as its coordinator. (The Legislature first authorized the State Engineer's Office to participate in snow surveys in 1918, but the program died from lack of funding in 1923. Snow surveys and dam safety, also established in 1929, are among DWR's oldest programs.)

Today, more than 50 state, national, and private agencies survey nearly 300 snow courses each winter. Snow water content data is received daily all season by automatic sensor

and provisions for the winter. The cabins serve as rest stops when the surveying work requires an overnight stay.

During the summer, much of the field work and preparation for the winter takes place. Automated snow sensor equipment is checked and needed repairs made. "These snow pillows remotely send their data via satellite to the California Data Exchange Center in Sacramento where the information is compiled into a centralized database," says Gehrke. "Everyone in the cooperative program can have access to CDEC, and the data is published monthly through the surveying period."



The surveyor sinks the sampling tube into the snowpack.

equipment, while snow survey teams sample the courses each month from January to May.

DWR SNOW TEAMS AT WORK

At DWR, Frank Gehrke heads the Snow Survey Section in the Division of Flood Management. "A snow surveyor's job is a year-round job," he says of the work done by staffers Bob Newton, Dave Hart, Matt Colwell, Dudley McFadden, Shawn Perkins, and six part-time members working out of Bishop. Before the first snowflakes hit the ground, team members trek to the high country to stock cabins with food



The tube is weighed on a scale suspended from a ski pole.

To advance the design of future automatic snow data collection networks, experimental equipment is installed so that it can be tested and evaluated through the winter season.

Snow course maintenance work also goes on. Courses are cleared of brush and end point markers checked. In heavy snowfall, trail markers, orange signs or license plates nailed high up in trees, can save surveyors time and lead them safely to their destination.

Back at headquarters, DWR snow surveyors are updating and verifying historic data, information provided by other agencies in the cooperative program. "We receive over 1,000 'snow note', forms on which measurements are recorded," says Gehrke. "These numbers are included in the Fall Report issue of Bulletin 120, Water Conditions in California. We have to check the notes for accuracy and sometimes make adjustments for certain conditions. It's a laborious task but it's an important quality control measure."

In January, the teams head out to the courses. Sacramento teams survey



The procedure is repeated another nine times to get an average for the course.

six courses along Highway 50, while the part-time surveyors cover 15 courses from the east side of the Sierra from February through May. "All of the members must know how to ski," says Gehrke of a job that sometimes demands traversing 10 to 15 miles and climbing more than 5,000 feet in a single day.

"The work can be hazardous. The surveyors are trained to avoid dangers like getting snowbound or caught in an avalanche. While they know how to

"A SNOW SURVEYOR'S JOB IS A YEAR-ROUND JOB."



"WATER CONTENT
OF FRESHLY
FALLEN SNOW IS
ROUGHLY 10
PERCENT"

handle emergencies, they also take precautions and are constantly vigilant about checking conditions before they take off."

THE ART OF SNOW SURVEYING

Cooperative snow survey teams, usually two to three individuals, measure nearly 300 courses along 400 miles of the Sierra Nevada and Cascade mountain ranges. Covering drainage areas from Kern River in the south to the Scott drainage basin in the north, each course is visited at least once a year by a snow survey team. Surveyors usually measure two to six courses a day, depending on the weather and distance between sites. They travel to the sites by ski, snowshoe, helicopter, snowcat, or snowmobile.

While it's been several decades since snow surveying methods were developed by Dr. Church, the concept of weighing the snowpack remains basically the same. An average snow course is 1,000 feet in length. The surveyor first sinks a snow sampling tube with a cutter edge into the snowpack, checking to see if the tube has hit the ground. After the tube is pulled out and soil cleared from its end, the tube is weighed on a scale suspended from a ski pole. The snow core is measured in ounces, its depth is recorded in inches. (The tube's diameter is such that one ounce of snow equals one inch of water.) The procedure is repeated another nine times, at points 50 to 100 feet apart, to get an average number for the course. The same points are sampled several times during the season to record changing conditions.

"Water content of freshly fallen snow is roughly 10 percent," says Gehrke, who began snow surveying for a private agency in 1980 and joined the Department's effort in 1987. "That typically translates to an inch of water from one foot of snow."

He adds that water content varies, depending on the type of snow—cold and powdery or wet and sticky—and time of the year. Later in the season, after the snowpack settles through periods of melting and freezing, it becomes heavier and denser.

Gehrke's oft-times partner Dave Hart serves as field activities coordinator responsible for collecting information from the various surveyors in the cooperative program and feeding the data into the CDEC computer. Staff hydrologists use the numbers to publish Bulletin 120 with its monthly (February to May) runoff forecasts. The bulletin also includes reservoir storage in major water distribution projects, snow water content, unimpaired runoff, seasonal precipitation and water conditions in the state's 10 hydrologic regions and for Central Valley streams.

"The bulletin is widely distributed," says Hart. "It is used by a variety of people and agencies throughout the state, such as public utilities, agricultural interests, project operators, municipalities, recreationists, and the news media."

SNOWPACK AND FORECASTS

Snow is vital to California's water supply because of the state's feast or famine conditions when it comes to precipitation. In the summer months, a high pressure area moves in from the North Pacific Ocean and

remains over northern California, effectively blocking the inland movement of moist marine air. That means most of the state's precipitation (rain and snow) falls in late fall and winter.

In the northern half of the state, from April through July, the snow melts and runs off into streams and creeks that eventually lead to four rivers—the Feather, Yuba, Sacramento and American Rivers—that make up the Sacramento River Index. The SRI is used to classify the water year (wet, normal, dry, critical) and in turn determines State Water Project and federal Central Valley Project deliveries.

"Measuring the water content of snow is one of the critical indicators in forecasting water supply for the year," says Maurice Roos, DWR's chief hydrologist. A second indicator is past runoff, including historical records, such as the 50-year average and the maximum and minimum of past years. Rainfall amounts is the third indicator used in forecasts.

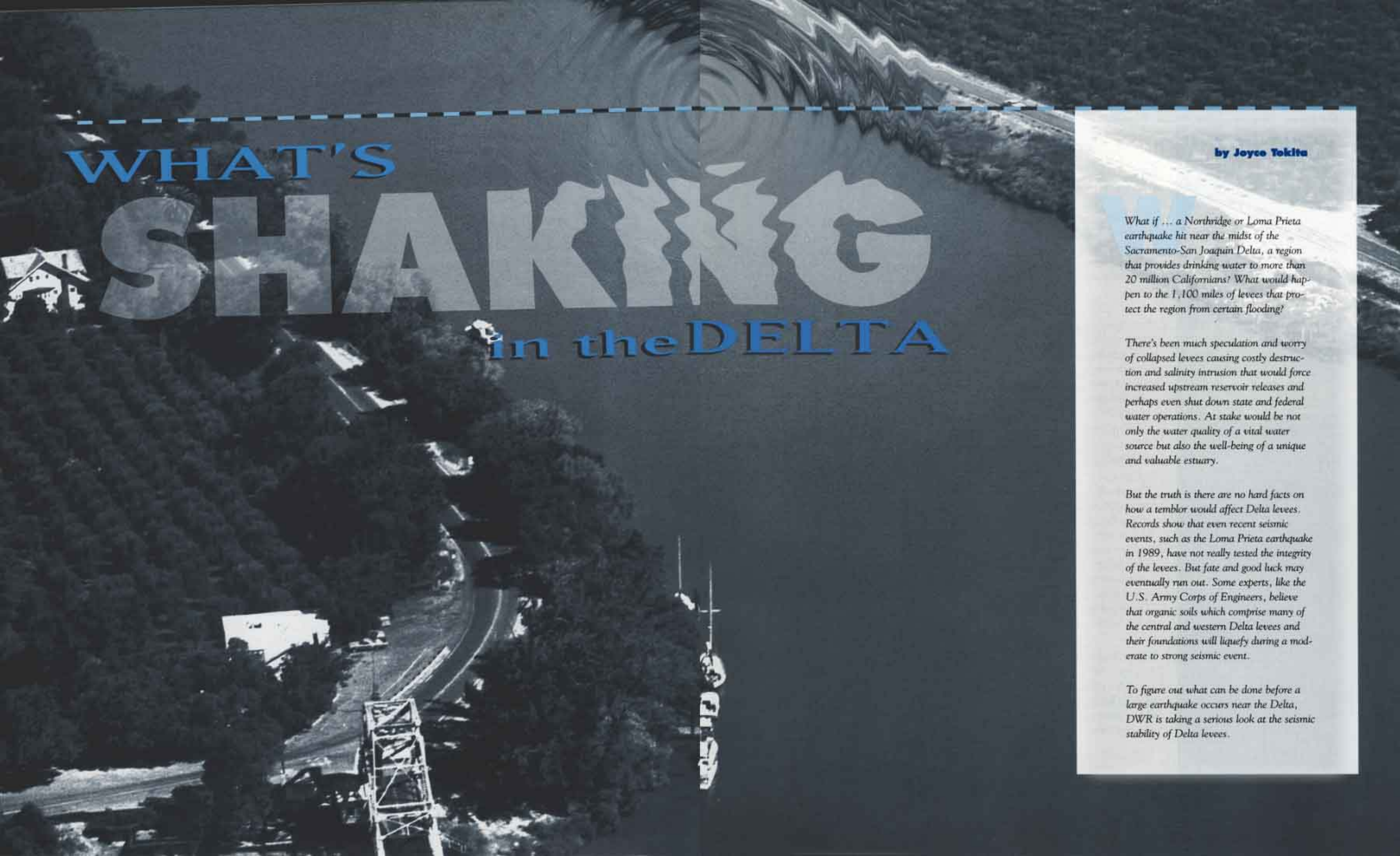
With these indicators, Roos says, by May we can usually predict to within 10 percent what the eventual runoff will be. "In May 1994, we forecasted a Sacramento River Index of 8 million acre-feet. The actual was 7.8 MAF."

Predicting the SRI impacts many people: The State Water Project and the Central Valley Project can forecast how much water must be released for downstream water quality and fisheries and how much water can be delivered to users. Water districts can plan their water supply strategies based on deliveries allocated by state and federal water operations. Reservoir op-

erators can determine how much capacity to leave for inflows from spring runoff. Public utilities can judge how big a role hydroelectric power will play in energy generation. Farmers can assess crop needs and planting and irrigation schedules. Municipalities can gauge whether their water supply will be ample for the summer or require mandatory rationing. And recreationists can anticipate good or bad conditions for skiing, rafting and other water sports.

"Water forecasts lead to better planning and management of the state's water resources, which benefits all Californians," says Roos. "And the Cooperative Snow Surveys is an important part of the effort."





WHAT'S

SHAKING

in the DELTA

by Joyce Yokita

What if ... a Northridge or Loma Prieta earthquake hit near the midst of the Sacramento-San Joaquin Delta, a region that provides drinking water to more than 20 million Californians? What would happen to the 1,100 miles of levees that protect the region from certain flooding?

There's been much speculation and worry of collapsed levees causing costly destruction and salinity intrusion that would force increased upstream reservoir releases and perhaps even shut down state and federal water operations. At stake would be not only the water quality of a vital water source but also the well-being of a unique and valuable estuary.

But the truth is there are no hard facts on how a temblor would affect Delta levees. Records show that even recent seismic events, such as the Loma Prieta earthquake in 1989, have not really tested the integrity of the levees. But fate and good luck may eventually run out. Some experts, like the U.S. Army Corps of Engineers, believe that organic soils which comprise many of the central and western Delta levees and their foundations will liquefy during a moderate to strong seismic event.

To figure out what can be done before a large earthquake occurs near the Delta, DWR is taking a serious look at the seismic stability of Delta levees.

Regional Faults



Source:
Seismic Stability of Delta Levees
(DWR 1992)

New Study

"It's most critical that we determine the potential for Delta soils to either amplify or dampen out earthquake motions," says Les Harder, program manager of a new seismic study of the region.

"Delta levees are sitting on tens of feet of soft peaty soils. If these organic soils amplify ground motions, the behavior can have consequences much like what happened during the Loma Prieta earthquake."

During the 1989 temblor, much of the most serious damage occurred along the margin of the San Francisco Bay, an area composed of soft soils. "Though all of those sites, such as the Marina District, the Cypress Freeway, the Bay Bridge, and Oakland Harbor Airport, were 50 to 60 miles away from the epicenter, the soft soils beneath them amplified weak earthquake motions as much as five times greater than bedrock," Harder says. "This is potentially what can happen in the Delta."

Harder, however, is quick to point out that one 1967 recording of a magnitude 4.5 temblor in Union Bay near Seattle, Washington showed that the fibrous peaty soils there actually dampened motions.

So the question remains: Will the Delta's peat soils hurt or help the levees? Data from the new study, coordinated by Harder and others in the Department, may begin to unravel the mystery.

Though the Delta levees have yet to experience significant ground motion, the region lies in a seismically active area. U.S. Geologic Survey experts say the San Francisco Bay region was seismically very active during the 1800s and early 1900s but has been relatively quiet since 1911. However, that quiet period appeared to end in 1979 with four moderate to large earthquakes occurring in the region since then. These events suggest that the region is entering a cycle of increasing activity. In fact, one of their studies predicts that a magnitude 7.0 earthquake, similar to the Loma Prieta event, has a 67 percent chance of occurring within the next 30 years in the San Francisco-Oakland area on either the San Andreas or Hayward Faults.

"Concern for Delta levees is prompted by the fact that earthquake activity appears to have changed in the last 10-20 years. Magnitudes are larger and occurrences have been on unknown faults," confirms Dave Kessler, head of Earthquake Engineering. His section purchased and helped install surface and subsurface accelerometers at four sites in the Delta—Clifton Court, Montezuma Slough, Staten Island, and Sherman Island. Kessler and staff will also operate and maintain the equipment as well as retrieve (via computer modem) and process the data.

"The new equipment is much more sophisticated than what was previously at existing sites," Kessler says. Previously installed equipment at eight other Delta locations—one that dates back to 1969, when planning was underway for the Peripheral Canal—contain accelerometers that record surface motion only. At the new sites, in addition to sensors at the surface, three subsurface instruments to measure ground movement will be

installed in boreholes in various depths down to 500 feet. The borehole drilling and casing installation for subsurface accelerometers were completed under the direction of the Project Geology Branch.

"Each instrument will contain three sensors that move in mutually perpendicular directions," explains Kessler. "That way, motion of a particle at depth can be reproduced and compared with one at the surface. Besides recording information at different geologic layers (peat, clay, sand, rock), the new equipment will provide digital data which can be manipulated and interpreted immediately."

**Consequences of
levee failures would
be devastating,
especially on the
western Delta islands,
which serve as
barriers to help stem
the tide of salt water
intrusion into the
interior Delta.**



**New earthquake
sensing equip-
ment will be located
on levees composed
of soft soils. Four
sites with different
foundations were
selected - including
Sherman Island
(above) where the
levee is very large,
with the peat soil
beneath around 35
feet thick.**

All four sites are located on levees composed of soft soils. "We picked areas with different foundations," adds Harder. "For example, at Sherman Island, the levee is very large, with the peat soil beneath around 35 feet thick; while at Clifton Court, the levee is smaller with smaller amounts of organics. Ideally, we'd like to see what happens when an earthquake or series of earthquakes trigger motions that would impact each site. That way we can learn how different organic soils behave under similar conditions."

The data obtained from the new equipment will document the kinds of ground motions created by earthquakes, assess whether the Delta's soft, organic soils will amplify or dampen earthquake movements, and estimate how well levees and other structures will fare under different levels of earthquake motion. Recordings will also be compared to computer models that can simulate different levee profiles (based on soil densities, foundation conditions and

other characteristics), then simulate different intensities of earthquake motion to project the effects. In this way, information from more commonly occurring smaller or distant earthquakes can be used to predict behavior for a future large earthquake.

"One earthquake won't settle all the questions," says Kessler. "In fact, it may raise other questions."

**Delta levees protect
a variety of habi-
tats that is home to
about 230 species
of birds, including
nearly half the
shorebirds and
waterfowl that
migrate on the
Pacific Flyway.**





Past Results, Future Outlook

No detailed evidence exists of how Delta levees have fared in past earthquakes. Reviews of past newspaper stories, engineering journals, and eye-witness accounts reveal no levee failure or even serious damage resulting from temblors. The most serious damage reported was during the 1906 San Francisco earthquake during which a Santa Fe railroad bridge at the Middle River crossing was displaced by about three feet.

"Historically, since reclamation began in the area, the Delta has experienced only low levels of shaking," says Les Harder, "so the levees have never really been tested."

There is a growing belief among geologists that the Delta area may include blind thrust faults. These are hidden faults that, when they rupture, don't show on the surface. The Northridge

Earthquake occurred along one. "Because there is no surface expression such as large cracks or offsets in the ground, you can't map the faults or see them in aerial photos," explains Harder. "But as demonstrated by the Northridge event, these types of earthquakes still produce a lot of shaking and damage."

Even fairly recent studies conducted over the past 12 years fail to fully reveal the region's seismic hazards. The results, however, are considered preliminary because of the long lengths of levees involved, the lack of information on the levees themselves and their foundations, and the question of whether organic soils would amplify or attenuate (dampen) ground motions.

"Historically, we haven't recorded much in the Delta because there is little instrumentation in the region, and the large earthquakes have occurred in other regions," says Dave Kessler.

Though limited, previous findings do point to certain vulnerable spots. A 1987 Corps of Engineers study shows that the central Delta is considered to have a moderate to high potential for liquefaction; and a 1992 Earth Sciences Associates evaluation predicts about a 90 percent probability that levees along the Delta's western edge will liquefy during an earthquake within the next 30 years. The Department's preliminary studies, documented in a 1992 Design and Construction report, also show the levees on the western edge of the Delta to be at risk within the next 30 years. This risk potential generally decreases towards the east side of the region.

Information from the new study will build on the database. "The more we know about the relative vulnerability of Delta levees, the better we can plan and be prepared," Harder says. "While it may not be economically feasible to upgrade most reaches to meet earthquake safety standards, we can pursue a rational approach of managing existing and future Delta facilities and resources."

What that means is too early to say. New study results will still be limited in scope. However, the Department is looking into conducting more extensive joint investigations with other agencies and universities.

"We do know that the potential for trouble in the Delta is great," adds Harder. "And we need to know the magnitude of those risks and raise the accuracy of our predictions."

**"The more we
know about the
relative vulnerability
of Delta levees, the
better we can plan
and be prepared."**





ACT

A Balancing

- SB 1866 and the Delta -

It is called the Jean Harvie Community Center, and it is pure Americana. Norman Rockwell could have painted it. The large, echoing room has a stage at one end, high ceiling and a polished hardwood floor. It can double as a basketball court, theater or a setting for the understated drama of real life. You can imagine a body of Yankee selectmen arguing over the town budget.

But now this Walnut Grove landmark is more than a community building. It is the meeting place for the Delta Protection Commission, which has been set a task that looks nearly impossible on its face—to craft a plan that would restore and protect all of the region's vital resources while recognizing the needs of those who depend on them.

The Delta is, in essence, all things to all people. Its 1,000 miles of waterways quenches the thirst of more than 20 million Californians; irrigates millions of acres of farmland; sustains local communities, industries and governments; and provides habitat to over 300 species of fish and wildlife. Located within the region are TV, radio and electrical transmission lines; natural

By Joyce Tokita and Alan Jones

gas production fields and pipelines; water canals and pipelines; wastewater treatment plants; highways; railroads; bridges; and two major ports in Stockton and Sacramento. Approximately 1,100 miles of levees protect more than 500,000 acres of prime agricultural land which produce \$500 million of income for the five counties within the Delta. Thousands of people visit towns like Locke and sights like the Grand Island Mansion for their rich cultural heritage. Plus, the Delta is a favorite haunt of boaters, anglers, bird watchers, waterskiers, and windsurfers.

But like many good things that eventually come to an end, the Delta has reached its nadir. Under the onus of all these competing demands, the health of the Delta is deteriorating. Fish populations have declined with introduced species changing the ecosystem. Islands continue to be threatened by floods. Water quality is threatened by salinity and pollution. Farmlands are encroached by development. Levees require large sums of money for repairs. Improved recreational opportunities are needed. And the list goes on.

Most who know the Delta recognize the problems. But, until recently, there lacked a process for solutions... or a regionwide plan for managing its valuable resources. In 1992, SB 1866 was passed to fill some of the void.

As part of his pledge to fix the Delta, Governor Wilson signed SB 1866, the Delta Protection Act of 1992, authored by Senator Patrick Johnston from Stockton. It declared the Sacramento-San Joaquin Delta as "a natural resource of statewide, national, and international significance, containing irreplaceable resources." Its intent was to "recognize, preserve, and protect those resources of the delta for the use and enjoyment of current and future generations."

To fulfill that mandate, the act established the Delta Protection Commission to prepare a comprehensive resource management plan for land uses within the primary zone of the Delta (see map on opposite page). The far-reaching plan will set policies for local governments and make recommendations that will touch every vital component of the Delta. The commission's goals include:

- preserve and protect agriculture,
- restore and improve the levee system,
- protect and preserve the Delta's cultural heritage,
- conserve and protect the fisheries and their habitat,
- preserve and protect open space and recreational opportunities,
- protect private property from trespass and vandalism,

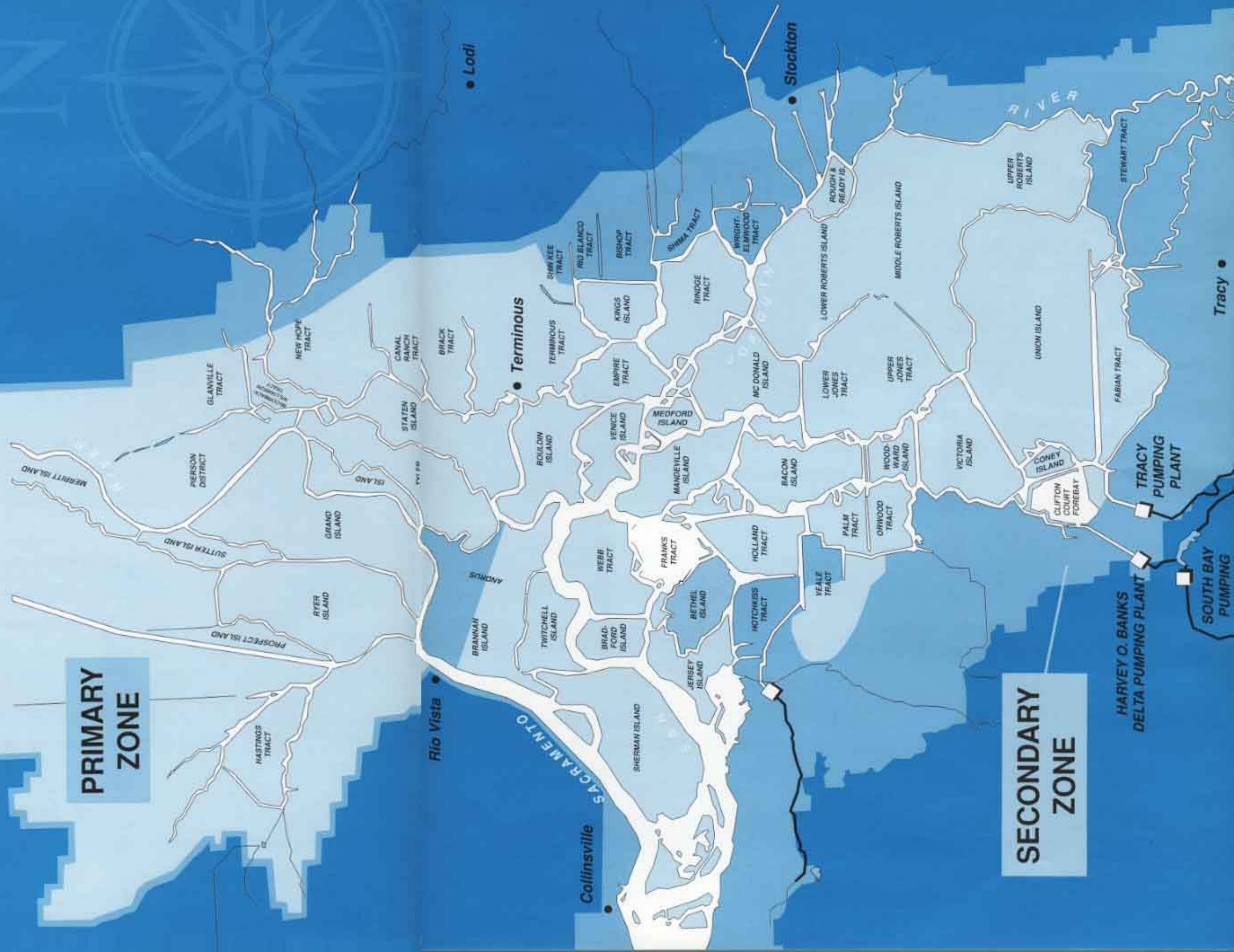
THE PRIMARY ZONE

The Primary Zone covers 487,625 acres of the legal Delta's 738,239 acres. About 50,000 acres within the zone is water area. Approximate percentages of area of each of the five counties contained: Contra Costa 8 percent, Yolo 10 percent, Solano 16 percent, Sacramento 28 percent, and San Joaquin 38 percent.

DWR owns 8,545 acres, which include Clifton Court Forebay, most of Twitchell Island and parts of Sherman Island. Other acreage is owned by the California Departments of Fish and Game and Parks and Recreation, the federal government, local agencies, and private parties.

NOZAFES

Sacramento-San Joaquin Delta



HOW

"How do we balance all of the competing demands on the Delta, such as by recreation and agriculture?"

- preserve and protect controlled public access and use of public lands and waterways,
- protect and preserve navigational and recreational boating,
- preserve and protect the Delta from development that would result in lost habitat or agricultural land, and
- promote creation of wildlife preserves through voluntary cooperative arrangements.

This was the agenda of the Delta Protection Commission as its 19 members first met in January 1993. The gathering included five representatives of boards of supervisors from each of five Delta counties (Sacramento, San Joaquin, Solano, Yolo and Contra Costa), three representatives from Delta cities, five members from regional reclamation districts, and six representatives from state government agencies (DWR, Fish and Game, State Lands Commission, Food and Agriculture, Parks and Recreation, Boating and Waterways). Together, they were to draft and adopt the plan by July 1, 1994.

But even with the most carefully laid plans and the best intentions, things can go awry. The July deadline passed not with a final plan but a draft plan.

"The original deadline was an optimistic one," says Margit Aramburu, the commission's executive director. "I think it reflects the difference between being on the outside and saying 'let's do this right away' and working on the inside (the DPC) and facing the realities of limited budget and staff, plus trying to incorporate public reviews and doing a worthwhile product that fully reflects all Delta interests."

To sort out the issues, Aramburu, with some outside assistance and input from technical advisory committees, prepared eight background reports. (DWR staff, such as Brenda Grewell, Ed Morris and Curt Schmutte, served as members or acted as consultants on such issues as agriculture, levees and the environment). Hearings were held on the reports that covered utilities and infrastructure, land use and development, water, agriculture, recreation and access, levees, environment, and implementation.

From these background reports were drafted the regional plan containing findings (key facts derived from background reports), policies (directions that counties must support through amendments to their general plans) and recommendations (additional directions for action which will

be carried out by agencies other than the counties such as DWR, other state agencies, environmental groups and non-profit organizations).

Public hearings were then held at Walnut Grove, Antioch, Stockton and Tracy, followed by extensive rewriting of the draft plan based on the many comments received.

At their February 1995 meeting, the Delta Protection Commission voted to adopt the revised plan.

"We feel pretty confident that the plan takes into consideration all of the Delta interests involved, and hopeful that these parties are in turn satisfied with the work of the commission," says Bob Potter, DWR's chief deputy director serving as a DPC commissioner.

Local governments — cities and counties within the Delta — must now amend their general plans, their rulebooks on growth, to match the regional plan. Future development will be allowed only after local governments find that development complies with standards set in the commission's resource management plan. The plan applies to the "primary zone," which includes most of the legally defined Delta but excludes the cities of Stockton, Tracy, Pittsburg, and Antioch. In the rest of the Delta, the "secondary zone," local governments retain jurisdiction over land use decisions.

The aim, Aramburu emphasizes, is for local government to retain control. The plan is intended to be used as a guide for local governments to ensure that certain policy areas are addressed within each local government general plan and that, within policy areas, uniform policies are adopted Delta-wide.



"We are continuing the work on regional planning that began in the 1970s, but with a different approach," she says. "The Delta Protection Act brought together all of the major parties (cities, counties, landowners, state agencies) interested in seeing a healthier Delta, and it put 'teeth' into its work by giving the commission authority to oversee local governments via an appeals process. But it still leaves regulation at the local level."

Once the plan is in place, the commission's role will be limited to that of hearing appeals of local land use decisions. It has handled one appeal by a Sacramento County farmer of the county's approval of a 20-acre subdivision on agricultural land. The commission upheld the action of the board of supervisors.

The concept of the Delta Protection Act, says Aramburu, was a partnership approach to solve regional problems.

"Not an adversarial relationship, bashing each other about. Most counties have done a pretty good job. If we can keep counties to what they've committed to, we will be fine on primary zone land use issues."

Ryan Broddrick, DPC commissioner and manager of the Department of Fish and Game's Region 2, agrees. "Local communities must look at the plan as a partnership with all of the other agencies and private interests that have control over the Delta," he says. "We had to share a common vision. Without that kind of synergy, it would have been difficult tackling the issues."

Even then, conflict is inevitable. While the ultimate goal of drafting a regional map was kept firmly in mind, each of the 19 commissioners came to the table knowing they also represented particular interests in the Delta. As did Steve Mello.

"As a representative of the North Delta Water Agency, I wanted to make sure that we accom-

plished our goals as a commission without reducing the landowners' property values, that we protect currently held entitlements, and that we encourage continued agricultural use," says Mello, who is a native of Walnut Grove and a second-generation Delta farmer. "We're concerned about the conversion of farmland to other uses and its effect on farm support industries and the tax basis of the special districts that provide the services upon which Delta residents depend."

Mello also wanted his participation to help educate the public about the importance of reclamation districts (he is a trustee and director of District No. 563) and the burden that the landowners have borne to maintain the levees. "For quite a few years, the landowners have been 'the goose that laid the golden egg' that funded routine maintenance costs of levees. The damage the levees suffer are not all natural. Some of the other beneficiaries of those levees, such as the state and

At its best, the plan will forge a delicate balance between the needs of the regions natural resources and demands of its users.

federal water operations and recreational boating, contribute to the damage and should pay for those costs."

Getting the plan to reflect the sometimes conflicting concerns and views of those involved was an arduous task in itself—further complicated by the very nature of the region the commission is mandated to save.

"How do we balance all of the competing demands on the Delta, such as by recreation and agriculture, for example?" asks Aramburu. It is a question that touches on the heart of the issues in the Delta and embodies the real crux of the kinds of solutions needed.

"The Delta provides benefits to a large number of people who don't even recognize it," says Broddrick. "Many have looked at the plan, to a large degree, in terms of what they see—either from an economic necessity or personal preference—the Delta should provide instead of thinking of the broader, long-term sustainability of the region."

At its best, the plan will forge a delicate balance between the needs of the region's natural

resources — better water quality, more habitat, improved flood protection, to name a few — and demands of its users — for water supply, irrigation and recreation. The success of that balancing act, however, will depend on how well others perceive it was crafted.

"I see our role as recognizing those demands and needs and knowing that in the goals we set, there will be compromises in all areas," says Broddrick. "But those compromises need to be seen as well thought out and justifiable, with the focus that this balance is needed to maintain the Delta system for future generations, not just the next harvest or the next boating or hunting season."

As for the future, no one knows for certain whether the commission will "sunset" in 1997 or continue in another form. But those who participated are optimistic about the commission accomplishing the goals that were set before them.


"I think the plan incorporates the interests of all of the varied parties involved in the Delta, such as the counties, cities, the landowners, and state

agencies," say Margit Aramburu. "Thanks to the leadership of DPC's chairman, Tom Torlakson (Contra Costa County supervisor), we've been able to keep focused on what needed to be done."

Says DWR's Bob Potter: "Our basic concern was urban encroachment into the Delta and to put some constraint on future development to protect the region's primary values — wildlife, agriculture and recreation. I think, despite our occasionally disparate views, we've worked effectively as a group to tackle the issues productively and come out with a workable plan."

For those people like Steve Mello who live in heart of the Delta, making the plan work gets a little more personal. "I see my interest as 'small potato', but it's all the potatoes I've got." •





The Graywater Zone

By Jeff Cohen

Picture this.

A street of quiet suburban homes with green lawns, flowerbeds and assorted trees. Well, not an unusual sight for California. But consider. The lawns grow, the flowers bloom and the trees blossom—without a single sprinkler or hose in sight.

No, you're not in the "Twilight Zone." But you could call it the "Graywater Zone."

This may be a suburban scene in California where residents can now take advantage of gray water—that is water that is reused from our shower, bath and laundry to keep our flowers, lawns, and trees healthy, even during a drought.

The idea of using graywater is not a new one. Most of us, at one time or another, have put a bucket of shower runoff on the bougainvillea. But the idea of doing it safely and conveniently with the larger amounts produced by the average household has posed a problem until recently.

Thanks to a team of public health, plumbing, and environmental professionals coordinated by the Department of Water Resources, Californians can now enjoy the benefits of graywater without its potential drawbacks.

THE PATH TO LEGALIZATION

The path to legalize graywater use in California is a story that has its origins in the drought of 1977. Homeowners in parched Marin County and Santa Barbara looked for an easy method to save prized landscaping. It was at that time that Larry Farwell, with the Goleta Water Department and later a graywater coordinator on loan to DWR, installed his own system on a trial basis. (It is still working today.)

Homeowners like Farwell, facing increased demands for water conservation in the home, confronted a Pandora's box of local graywater regulations. Builders and manufacturers realized standardization in graywater systems manufacturing and installation was needed to avoid public health problems. The use of graywater was, for the most part, forbidden in California. At the time, only one state, Texas, allowed its use.

As the drought moved into high gear in 1992 so did the movement to make the legal and safe use of graywater a reality. The State Legislature—striving to set a standard to protect public health, optimize the use of residential water, and provide consistency for manufacturers of systems—pushed for a single standard.

Legislation to legalize its use and standardize graywater systems swiftly passed through the State Legislature in 1992. The Graywater Systems for Single Family Residences Act, Assembly Bill 3518, was signed by Governor Wilson in 1993, and by 1994, amendments to the plumbing code were approved, establishing the groundrules for installation and building permit approval.

The legislation had specified DWR as the agency to coordinate the adoption of standards that would be practical, affordable, and protect public health. Farwell, by this time the Department's graywater coordinator, and Marsha Prillwitz, DWR's landscape program manager who drafted pioneering legislation for landscape management plans for cities, teamed up with an advisory group of environmental health officers, California Department of Health Services officials, plumbers, graywater system manufacturers, and environmentalists. Their task was to come up with standards for

safe and effective systems. It proved to be a daunting assignment, with each party having specific concerns. Public health officials took a very strict stance in regard to the presence of pathogens in the soil; while manufacturers wanted to protect their businesses and not price themselves out of the market.

SAFETY CONCERNS

As adoption of graywater use was being considered, public health was a major issue. Standards require subsurface distribution of graywater, but concern centered on the potential for surface pooling during irrigation. After months of discussion and debate on the issue, a breakthrough came with the results of a technical report by the Center for Irrigation Technology at Fresno State University, headed by Dr. Ken Solomon. He and his staff conducted research on maximum application rates for different soil types, that is they sought to find out how fast different soil types would absorb graywater before pooling began on the surface where it could possibly come into contact with people or pets. (Graywater standards now reflect those findings.)

The next step was to seek adoption of the standards by the Building Standards Commission, which sets the rules for construction statewide. Farwell and Prillwitz spent the better part of 15 months hammering out details with health and building officials over the depth, size and location of graywater systems. On the third try before the commission, the standards were adopted and went into effect in November 1994.

"It was a challenge to meet all the needs of different interest groups and come up with standards that work," says Prillwitz, who has since been named DWR's graywater coordinator.

Installation of sometimes complex approved graywater systems will eventually get easier. "What is complicated and intimidating now will become less so in time, as people become more familiar with the standards and the systems," she says. Manufacturers are working on a prefabricated system, much like packaged drip irrigation systems.

Graywater standards require that graywater must remain below ground and that human contact with graywater be avoided.

The California Department of Health Services, an active participant in developing the standards, stipulated that installers and landscapers must install pipes nine inches below the surface to minimize human contact. (If a member of a household is ill or infected, graywater may carry infectious bacteria or viruses. However, unless a person drinks the contaminated graywater or consumes unwashed vegetables that were irrigated with graywater, its use is safe.)

A Department guidebook spells out the regulations and provides advice for homeowners, plumbers and landscapers. The Graywater Guide can be obtained from DWR's Publications Unit, 1416 Ninth Street, Room 338, Sacramento, California, phone (916) 653-1097.

The Department is also looking forward to a series of graywater workshops this year to introduce the standards to a wider audience of water districts, building inspectors, and landscape architects and contractors.

Graywater users should heed a few simple precautions.

- Don't drink or play in graywater.
- Don't mix potable (drinking) water with graywater.
- Don't allow anything that may be eaten to come into contact with graywater.
- Don't allow graywater to pond on the surface or run off the property.

THE FUTURE OF GRAYWATER

Does graywater have a future as a widespread conservation technique? That remains to be seen. A study* of eight graywater sites by the City of Los Angeles concluded that the potential availability of graywater ranged from 13 to 65 percent of total household water use. Recently, Marin Municipal Water District surveyed some of its customers in April 1994 and found that almost seven percent said they were using some sort of

*The City of Los Angeles Graywater Pilot Project, "Graywater Is As Safe As Low Voltage Electricity," by Dr. Bohman Skeikh, presented at Conserve '93 Conference, Las Vegas.

graywater system. Of that percentage, almost half reused graywater on their landscapes.

Farwell estimates a family of four could produce from 100 to 160 gallons of graywater each day. In some coastal areas, such as Santa Barbara, this may be enough to irrigate much of the landscape. In inland areas, such as southern San Joaquin Valley where peak summer residential water use may average up to 1,000 gallons a day in July, graywater would irrigate much less.

The price of installing a system, from \$800 to \$3,000, may pose a barrier for some homeowners. Initially the expense will probably limit graywater systems to more affluent areas where residential water use is high and savings from such systems more likely. Graywater systems are much in evidence in Palo Alto on the San Francisco peninsula and other areas where water rates are among the highest in the state. It also appears that the higher the home's water use, the shorter the time it will take to pay back the cost of installation. A recent Los Angeles study showed that savings from graywater reuse in low and median water-using residences totaled a maximum of \$100 per year. The savings jumped from \$350 to \$700 annually for high and very high water-using residences.

The future of graywater will depend on how the public treats the prospect of future water shortages—either as occasional nuisances or as recurring events. Home builders will install graywater systems when they can recover the cost from buyers. Homeowners will install graywater systems when they are considered a cost-effective, safe way of combatting perennial droughts. The California Urban Water Conservation Council identifies graywater as a potential "best management practice (BMP)," among other water conservation practices such as installing low flow plumbing fixtures and auditing large landscape irrigations. Data on possible savings from these and other BMPs will figure into the 1998 update of the California Water Plan. Meanwhile, additional case studies of graywater sites will be conducted so that more data can be analyzed before estimating the potential effect of graywater reuse on urban water demands.

GRAYWATER IS

• untreated household waste water which has not come into contact with toilet waste.

It includes used water from bathtubs, showers, bathroom wash basins, and water from clothes washing machines and laundry tubs.

It does not include waste water from kitchen sinks, dishwashers, or laundry water from soiled diapers.

Plants that like graywater:

bougainvillea
fan and date palms
golden rain tree
rosemary
agapanthus
Bermuda grass
honeysuckle
Australian tea tree
Italian stone pine
purple hopseed bush
oaks
Arizona cypress
cottonwood
olive
ice plant
oleander
juniper
many native plants

Plants that won't like graywater:

rhododendrons
hydrangeas
azaleas
violets
impatiens
begonias
ferns
gardenias
philodendrons
camellias
primroses
star jasmine
redwoods



Jim Davies measures river flow from a cable car, which is used when the water is too deep (about four feet or more) for wading measurements. A current meter and a weight are attached to a cable that he lowers into the water from the car. With them, Davies can obtain the stream depth and flow velocity.



BY DAN WIGHTMAN

PHOTOGRAPHY BY STEVE PAYER

Adequately describing what the San Joaquin District's water resources technicians do so expertly takes a lot of punctuation. Their tasks include monitoring and evaluating the state's water resources; gathering data on surface and ground water quantity and quality; storing collected data; and dispensing it in various forms to users inside and outside the Department. They also coordinate with their counterparts in DWR's three other districts to avoid duplication of effort; conduct land use surveys of agricultural and urban landscapes; and work closely with the State Water Contractors to be sure water deliveries and billings are in order.

This triple-completion well is used to monitor water levels and collect water quality samples from three discrete depths (deepest zone is about 700 feet below surface). A technician measures the well through a sounding tube with an acoustic probe (the device on the lid), which sends a sound wave down the well. When the wave bounces off the water surface, it provides a digital readout of the depth to water.



"It's a demanding job that's changed a lot in recent years," comments Tony Camoroda, acting chief of the Ground Water Data Unit. "As our databases have continued to grow, the traditional collection and distribution techniques that worked just fine in the past haven't kept pace. These days, users want their data on computer disks or printouts — and they want it now! Our job is to give them what they need in the forms they can put to immediate use. To maintain excellence, we must keep up with the demand."

Modern needs aside, the gathering of water data still hinges on traditional methods that have proven effective over long periods of time. According to Larry Baxter, chief of the Surface Water Data Unit, precision, patience and adherence to practical procedures are key to the District's overall data-gathering effort. The men and women who collect the data must be patient, skilled, dedicated, and careful. If they are otherwise, the statistics they gather will be faulty or fragmentary — and of little value.

Presently, San Joaquin District technicians spend much of their time collecting data on ground water levels and surface water flows in the San Joaquin Valley. Some of this data they gather themselves, with the help of manual and electronic devices. Others they obtain from the U.S. Bureau of Reclamation and cooperating agencies. In all, techs log more than 13,000 separate ground water level measurements, and more than 10,000 surface water level measurements onto Department databases each year. The result is a highly accurate, pinpoint accounting of (1) spring and fall depths to ground water and (2) seasonal river depths and temperatures in critical Valley locations. These data are vital to DWR managers and members of the private sector, who use the measurements to gauge the impact of ground water pumping and recharge, as well as surface water diversions.

Techs store these data within the District and make them available in a variety of forms. "We get at least three or four data requests a day," says Camoroda. "Users tell us that our numbers are dependable and

our period of record long enough to meet their needs... Our files date back to the 1920s, and they're fairly inclusive. What's more, people reimburse us for staff time and copying costs to obtain the data from our files. For the most part they're glad to do so because we're giving them something they really need, and our turnaround time is excellent."

Besides determining water levels, techs measure the quality of ground and surface water in critical Valley locations. Budget cuts and rising costs have reduced the scope and frequency of this analysis, but water quality assessment remains one of the District's most valuable data-gathering activities.

Within the Department, many program managers require frequent analyses of ground and surface water quality to monitor land subsidence and track the changing impacts of planning and construction activities, environmental needs, water operations and pumping programs, droughts, or storms. Outside DWR, planners, growers, and environmental specialists depend on the Department's water quality data to evaluate the impact of past and proposed land and water use practices.

Working together with DWR's laboratory crew in Bryte, California, techs tailor water sampling to individual needs.

This year, for example, Jose Faria, manager of the District's Aqueduct Protection and Flood Management Section, has contracted with Camoroda, Baxter, and their support teams to update data on ground water quality and surface water flows in the area about 60 miles southwest of Fresno, where the California Aqueduct crosses a stream called Arroyo Pasajero. The quality of the ground water in this area has not been checked for seven years, and surface water flow fluctuates from storm to storm. Faria needs to know the current quality and runoff volume to help determine how arroyo floodflows have impacted ground water quality and surface water storage near the aqueduct. Working directly with the techs, Faria can stipulate where and when the sampling will occur. He can also designate the exact constituents he wants the water tested for.



Above: Equipment used to measure surface water flow includes (from left to right) a screwdriver, current meter and bar, a stopwatch, and a wading rod. Typically, the meter is attached to the wading rod and lowered into the stream to measure velocity.

Right: Using the equipment, Chuck Serpa makes a wading measurement of streamflow.





Working as a team is handy when it comes to safety, but teamwork plays a greater role in getting the job done quickly and efficiently. Chuck Serpa makes wading measurements of stream depth and flow velocity, while Jim Davies records them.

"It's a real blessing to have these services available in-house," says Faria. "Our techs know the territory and the techniques needed to sample it effectively. They excel at this work, and they're willing to perform it on short notice — even in terrible weather. We couldn't get service any better than this from any consultant."

At the height of the state's record rainstorms, during the first few weeks of 1995, techs put in long hours along Arroyo Pasajero measuring floodflows into a ponding basin west of the California Aqueduct. This cold, uncomfortable, and potentially dangerous duty resulted in vital quality and flow data that Faria and others needed to ensure the integrity of SWP supplies and to protect the aqueduct itself.

Keen devotion to sensible safety practices minimizes on-the-job dangers that techs face. Still, anyone collecting samples in or near deep, fast-flowing water runs a risk of having an accident.

"We've been careful, and we've been fortunate," says Gil Pineda, a technician in the Surface Water Data Unit. "Aside from some slips and scrapes, we haven't had any real accidents to speak of. But the threat is definitely there. Techs in other departments have been seriously hurt while collecting data. That's why our techs are strongly encouraged to sample cautiously, and discouraged from working alone in the field. There's usually a partner to help out if you get in a jam, or to compare notes with if you're unsure of how to proceed...All in all, it's a good, safe system."

Safe, yes — and ever more demanding as budgets shrink and requests for data services continue to swell.

"Considering the size of our staff and the hits our funding has taken, I'm impressed with what we're able to do," says District chief Lou Beck. "Our system is set up to serve the needs of others, and we continue to do that remarkably well...Credit goes to our techs. They're vital to the District and the Department, as well as to the public. All in all, their contributions are outstanding."

Along Suisun Slough near Grizzly Bay lies an underwater nursery of sorts. Its finned charges are striped bass, a fish that environmental and fishing groups say have declined about 65 percent from levels present in the 1970s. Within this nursery of floating netted pens swim more than 240,000 striped bass salvaged from the Skinner Fish Facility.

Fed and cared for daily for a year, the striped bass are ready for release when they reach 8-10 inches. However, whether or not they are placed back into the Delta will depend on whether the bass are negatively impacting the endangered winter-run

chinook salmon or the threatened Delta smelt — a decision to be made by the Department of Fish and Game, U.S. Fish and Wildlife Service, and National Marine Fishery Service. "The adult striped bass is at the top of the Delta food chain," says Steve Ford, project manager for the Department. "It's a voracious eater of other fish."

Whatever the eventual decision, the floating nursery has proven that it improves bass survival. Nearly 90 percent of the striped bass raised there survive to yearlings, compared to about 10 percent of salvaged fish that are immediately released back to the Delta. One contributing factor is

Pictorial: DELTA'S FLOATING NURSERY



that the pen-reared fish are protected from predators and have a more reliable food supply. Pen-reared bass may also have an advantage over bass reared in traditional land-based hatcheries because they are raised under conditions that are part of their normal existence in the Delta. The pens are also transportable, capable of being towed to different locations to get optimal water quality and water temperatures for the fish.

DWR reimburses Fish and Game for the cost of rearing those fish that are released to the Bay-Delta to offset bass lost at Banks Delta Pumping Plant.

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